~~Designation:B438/B438M–05~~ Designation: B 438 – 08

Standard Specification for ~~Bronze Powder Metallurgy (P/M) Bearings (Oil-Impregnated)~~Bronze-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)[1]

This standard is issued under the fixed designation ~~B438/B438M;~~B 438; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

~~*This standard has been approved for use by agencies of the Department of Defense.*~~

1. ~~Scope~~

~~1.1This specification covers sintered bronze, oil-impregnated bearings made primarily from elemental copper, tin, lead, and graphite powders. The manufacturer may, at his discretion, use prealloyed bronze powder in the mixed powder.~~

~~1.2This specification covers the following variables:~~

~~1.2.1*Grades*—Available in three bronze base compositions identifiable by different graphite contents and one leaded bronze grade.~~

~~1.2.2*Type*—Grades 1 and 2 are available in four types described by specific density ranges. Grade 3 is available in two types and Grade 4 is available in one type.~~

~~1.3Bearings ordered to this specification will normally be sized after sintering and will be impregnated with a lubricating oil unless otherwise specified by the print.~~

~~1.4The values stated in either inch-pound or SI units are to be regarded separately as standard. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.~~

~~1.5The following safety hazards caveat pertains only to the test methods described in this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*~~ Scope*

1.1 This specification covers porous metallic sleeve, flange, thrust and spherical bronze-base bearings that are produced from mixed metal powders utilizing powder metallurgy (PM) technology and then impregnated with oil to supply operating lubrication.

1.2 Included are the specifications for the chemical, physical and mechanical requirements of those bronze-base PM materials that have been developed and standardized specifically for use in the manufacture of these self-lubricating bearings.

1.3 This specification is applicable to the purchase of bronze-base bearings (oil-impregnated) that were formerly covered by military specifications and are intended for government or military applications. Those additional government requirements that only apply to military bearings are listed in the Supplementary Requirements section of this specification.

1.4 This specification acccompanies Specification B 439 that covers the requirements for Iron-Base Powder Metallurgy (PM) Bearings, (Oil-Impregnated).

1.5 Typical applications for bronze-base bearings are listed in Appendix X1.

1.6 Bearing dimensional tolerance data are shown in Appendix X2, while engineering information regarding installation and operating parameters of PM bearings is included in Appendix X3. Additional useful information on self-lubricating bearings can be found in MPIF Standard 35 and the technical literature.[2]

1.7 With the exception of density values for which the g/cm^3 unit is the industry standard, the values stated in inch-pound units are to be regarded as standard. The SI equivalents of inch-pound units, shown in parenthesis, have been converted in accordance with IEEE/ASTM SI 10, may be approximate and are only for information.

1.8 *The following safety hazards caveat pertains only to the test methods described in this specification. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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[1] This specification is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.04 on Bearings.

Current edition approved ~~Nov.~~June 1, ~~2005.~~2008. Published ~~November 2005.~~July 2008. Originally approved in 1966. Last previous edition approved in ~~2004~~2005 as B 438/B 438M – 0~~4~~5.

[2] ~~For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.~~

[2] *Machine Design Magazine*, Vol 54, #14, June 17, 1982, pp. 130-142.

***A Summary of Changes section appears at the end of this standard.**

2. Referenced Documents

2.1 *ASTM Standards:* [3]

B 243 Terminology of Powder Metallurgy

B 328 Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Metal Structural Parts and Oil-Impregnated Bearings

B 439 Specification for Iron-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)

B 939 ~~Test Method for Radial Crushing Strength, K, of Powder Metallurgy (P/M), Bearings and Structural Materials~~ Test Method for Radial Crushing Strength, ***K***, of Powder Metallurgy (P/M) Bearings and Structural Materials

B 946 Test Method for Surface Finish of Powder Metallurgy (P/M) Products

E 9 ~~Test Methods of Compression Testing of Metallic Materials at Room Temperature~~ Test Methods of Compression Testing of Metallic Materials at Room Temperature

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

2.2 ~~*Government Standards:*~~ *MPIF Standard:*

~~MIL-PRF-6085Lubricating Oil: Instrument, Aircraft, Low Volatility~~ MPIF Standard 35 Materials Standards for PM Self-Lubricating Bearings[4]

2.3 *IEEE/ASTM Standard:*

~~MIL-PRF-17331Lubrication Oil: Steam Turbine and Gear, Moderate Service~~ SI 10 American National Standard for Use of the International System of Units (SI): The Modernized Metric System[3]

2.4 *ISO Standard:*

~~FED-STD-151 Metals Test Method~~

~~2.3 *MPIF Standard:*~~

~~MPIF Standard 35Materials Standards for P/M Self-Lubricating Bearings~~ ISO 2795 Plain Bearings Made from Sintered Metal—Dimensions and Tolerances[5]

2.5 *Government Standards:*

MIL-PRF-6085 Lubricating Oil: Instrument, Aircraft, Low Volatility[6]

QPL-6085 Lubricating Oil: Instrument, Aircraft, Low Volatility[6]

MIL-PRF-17331 Lubrication Oil, Steam Turbine and Gear, Moderate Service[6]

QPL-17331 Lubricating Oil, Steam Turbine and Gear, Moderate Service[6]

MIL-B-5687 Bearings, Sleeve, Washers, Thrust, Sintered, Metal Powder, Oil-Impregnated, General Specification For[6]

MS17795 Bearing, Sleeve, Plain, Sintered Bronze, Oil-Impregnated[6]

MS17796 Bearing, Sleeve, Flanged, Sintered Bronze, Oil-Impregnated[6]

MS21783 Bearing, Washer, Thrust, Sintered Bronze, Oil-Impregnated[6]

3. ~~Ordering Information~~

~~3.1Orders for bearings under this specification shall include the following information:~~

~~3.1.1Dimensions and tolerances (Section 9~~Terminology

3.1 *Definitions*—The definitions of the terms used in this specification are found in Terminology B 243. Additional descriptive information is available in the Related Materials section of Volume 02.05 of the *Annual Book of ASTM Standards* .

4. Classification

4.1 This specification uses the established three-part alphanumeric PM Material Designation Code to identify the nonferrous materials used for self-lubricating PM bearings. The complete explanation of this classification system is presented in Annex A1.

4.2 The following standard oil-impregnated bronze-base bearing material compositions are contained in this specification:

4.2.1 *Prefix CT—Bronze*:

CT-1000-K19—Bronze with 24 % oil
CT-1000-K26—Bronze with 19 % oil
CT-1000-K37—Bronze with 12 % oil
CT-1000-K40—Bronze with 9 % oil

4.2.2 *Prefix CTG—Bronze-Graphite* :

~~[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.~~

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

~~[4] Available from Metal Powders Industries Federation (MPIF), 105 College Road East, Princeton, NJ 08540–6692, USA.~~

[4] Available from MPIF, 105 College Road East, Princeton, NJ 08540, telephone (609) 452-7700.

[5] ISO standards are available from the American National Standards Institute (ANSI), 16 West 42nd Street, New York, NY 10036, (212) 642-4900.

[6] Available from Standardization Documents Order Desk, Bldg 4, Sec. D, 700 Robbins Ave, Philadelphia, PA 19111-5094. Electronic copies of military specifications may be obtained from http://assist.daps.dla.mil/.

CTG-1001-K17—Bronze, 1 % graphite with 22 % oil
CTG-1001-K23—Bronze, 1 % graphite with 17 % oil
CTG-1001-K30—Bronze, 1 % graphite with 9 % oil
CTG-1001-K34—Bronze, 1 % graphite with 7 % oil

4.2.3 *Prefix CTG—Bronze-High Graphite*:

CTG-1004-K10—Bronze, 4 % graphite with 11 % oil
CTG-1004-K15—Bronze, 4 % graphite with a trace or up to 8 % oil

4.2.4 *Prefix CTG-MOD—Bronze-Lead-Graphite (Military Grade)*:

CTG-1001-K23-MOD—Bronze, 3 % lead, 1 % graphite with 17 % oil

4.2.5 *Prefix CFTG—Bronze-Iron-Graphite (Diluted Bronze)*:

CFTG-3806-K14—Bronze, 40 % iron, 0.75 % graphite with 22 % oil
CFTG-3806-K22—Bronze, 40 % iron, 0.75 % graphite with 17 % oil

5. Ordering Information

5.1 Purchase orders or contracts for bronze-base, oil-impregnated bearings covered by this purchasing specification shall include the following information:

5.1.1 A copy of the bearing print showing dimensions and tolerances (Section 10),

~~3.1.2Grade and type (see Tables 1-5~~

5.1.2 Reference to this ASTM Standard, including date of issue,

5.1.3 Identification of bearing material by the PM Material Designation Code (section 4.2),

TABLE 1 Chemical Requirements (Composition, %)

Material Designation Code	Chemical Requirements						Physical Requirements		Mechanical Require	
	Copper mass %	Tin mass %	Lead mass %	Graphitic Carbon mass %	Iron mass %	All Others mass %	Impregnated Density g/cm^3	Content Oil vol %	Radial Crushin Strength, K 10^3 psi	(MP
Bronze										
CT-1000-K19	bal	9.5-10.5	Grade 1	0.3 max	1.0 max	1.0 max	6.0-6.4	24 min[A]	19 min	(130 mi
~~CT-1000-K26~~	~~bal~~	~~9.5-10.5~~	~~Grade 2~~	~~Grade3~~	~~Gradex~~	~~1.0 max~~	~~6.4-6.8~~	~~19 min~~	~~26 min~~	~~(180 mi~~
CT-1000-K26	bal	9.5-10.5	Grade 2	0.3 max	1.0 max	1.0 max	6.4-6.8	19 min	26 min	(180 mi
~~Copper~~		~~87.2-90.5~~		~~85.7-90.0~~	~~82.8-88.3~~	~~80 max~~	~~6.9-88.2~~	~~12 min~~	~~37 min~~	~~(260~~
CT-1000-K37	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	6.8-7.2	12 min	37 min	(260 mi
~~Tin~~		~~9.5-10.5~~		~~9.5-10.5~~	~~9.2-10.2~~	~~9.5-10 max~~	~~7.52-7.6~~	~~9 min~~	~~40 min~~	~~(280 mi~~
CT-1000-K40	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	7.2-7.6	9 min	40 min	(280 mi
~~Graphite~~		~~0-0.3~~		~~0.5-1.8~~	~~2.5-5.0~~	~~0.50-1.75~~				
Bronze-Graphite										
~~Iron, max~~		~~1.0~~		~~1.0~~	~~1.0~~	~~1.0 max~~	~~6.0-6.4~~	~~22 min[B]~~	~~17 min~~	~~(120 mi~~
CTG-1001-K17	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	6.0-6.4	22 min[B]	17 min	(120 mi
~~TotG-1001-K23~~	~~bal other elements~~	~~9.5-10.5~~	~~by difference, max~~	~~1.0~~	~~1.0~~	~~1.0~~		~~17 min~~	~~23 min~~	~~(160.5~~
CTG-1001-K23	bal	9.5-10.5	by difference, max	0.5-1.8	1.0 max	1.0 max	6.4-6.8	17 min	23 min	(160 mi
~~Lead~~						~~2.0-4 max~~	~~6.8.7.2~~	~~9 min~~	~~30 min~~	~~(210 mi~~
CTG-1001-K30	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	6.8.7.2	9 min	30 min	(210 mi
~~Zinc, max~~						~~0 max~~	~~7.75.6~~	~~7 min~~	~~34 min~~	~~(230 mi~~
CTG-1001-K34	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	7.2-7.6	7 min	34 min	(230 mi
~~Nickel, max~~						~~0.35~~				
Bronze-High Graphite										
~~Antimony, max~~						~~0 max~~	~~5.2~~	~~11 min~~	~~10 min~~	~~(70 min)~~
CTG-1004-K10	bal	9.2-10.2	—	2.5-5.0	1.0 max	1.0 max	5.8-6.2	11 min	10 min	(70 min)
CTG-1004-K15	bal	9.2-10.2	—	2.5-5.0	1.0 max	1.0 max	6.2-6.6	[C]	15 min	(100 mi
Bronze-Lead-Graphite (Military Grade)										
CTG-1001-K23-MOD[D]	bal	9.5-10.5	2.0-4.0	0.5-1.75	1.0 max	0.5 max	6.4-6.8	17 min	23 min	(160 mi
Bronze-Iron-Graphite (Diluted Bronze)										
CFTG-3806-K14	bal	5.5-6.5	—	[E]		36.0-40.0[F] 2.0 max	5.6-6.0	22 min	14-35	(100-24
CFTG-3806-K22	bal	5.5-6.5	—	[E]		36.0-40.0[F] 2.0 max	6.0-6.4	17 min	22-50	(150-34

[A] 3 and radial crushing strength shall be 15 000 psi (100 MPa) minimum.
[B] For an oil content of 25 % min, density range shall be 5.8-6.2 g/cm^3 and radial crushing strength shall be 13 000 psi (90 MPa) minimum.
[C] At maximum graphite (5 %) and density (6.6 g/cm^3), this material will contain only a trace of oil. At 3 % graphite and 6.2-6.6 g/cm^3 density, it shall contain 8 vol% (min.) of oil.
[D] Additional chemical requirements are: Zinc–0.75 % max, Nickel–0.35 % max, Antimony–0.25 % max.
[E] Graphitic carbon content is typically 0.5-1.3 %; total carbon shall be 0.5-1.3 %.
[F] The iron portion may contain 0.5 % max metallurgically combined carbon.

NOTE—Grade 4 to be used for special government needs.

~~3.1.3Wet density specification (Table 2 and Table 3), and~~
~~3.1.4Oil type.~~

~~4.~~

5.1.4 Request for Certification and Test Report documents, if required (Section 16),
5.1.5 Type and grade of special Lubricating Oil, if required (section 6.2 or S2.2),
5.1.6 Instructions for Special Packaging, if required (Section 17).
5.2 Those additional government requirements necessary on orders for military bearings are prescribed in the Supplementary Requirements section.

6. Materials and Manufacture

~~4.1Sintered bronze bearings shall be made by molding or briquetting metal powder mixtures to the proper density. The green bearing shall be sintered at a time–temperature relationship to produce a microstructure that is essentially alpha bronze and contains no tin-rich phases visible at 300×. Sintered bronze bearings are normally sized after sintering to maintain the dimensional characteristics required of the bearing. After sizing and inspection, they are impregnated with a lubricating oil unless otherwise specified.~~

~~5.~~

6.1 *Porous Metallic Bearing*:
6.1.1 Sintered bronze-base bearings shall be produced by first compacting pre-alloyed bronze or elemental copper and tin powders and any other additives appropriate for the composition to the proper density and bearing configuration.
6.1.2 The green bearings shall then be sintered in a protective atmosphere furnace for a time and temperature relationship that will produce the required sintered bronze-base PM material.
6.1.3 After sintering, the bronze-base bearings are normally sized to achieve the density, dimensional characteristics, concentricity and surface finish required of the metallic bearing.
6.2 *Oil for Operating Lubrication*:
6.2.1 The interconnected or open porosity in the bearings shall be filled to the required volume with lubricating oil, either by an extended soaking in the hot oil or preferably by a vacuum impregnation operation.
6.2.2 A medium viscosity petroleum oil is normally used for most bearing applications, but extreme operating conditions such as elevated temperatures, intermittent rotation, extremely low speeds or heavy loads may require a synthetic lubricant or an oil with a different viscosity.
6.2.3 Unless otherwise specified by the purchaser, a high-grade turbine oil with antifoaming additives and containing corrosion and oxidation inhibitors, having a kinematic viscosity of 280 to 500 SSU [$(60 \times 10^{-6}$ to 110×10^{-6} m^2/s), (60 to 110 cSt)] at 100°F (38°C) is normally used as a general purpose lubricating oil.

7. Chemical Composition

~~5.1The material shall conform to the requirements as to the chemical composition prescribed in~~
7.1 *Chemical Composition Specifications*—Each bronze-base PM bearing material shall conform to the chemical requirements prescribed in Table 1 when determined on a clean test sample from oil-free bearings.
7.2 *Limits on Nonspecified Elements*— By agreement between the purchaser and the supplier, limits may be established and chemical analyses required for elements or compounds not specified in Table 1.

~~6.~~

8. Physical Properties

~~6.1*Density*—The density of bearings supplied impregnated with lubricant shall be within the limits prescribed in Table 2 and Table 3, when determined in accordance with Test Method B328.~~
~~6.2~~
8.1 *Oil Content*~~—Oil content of bearings shall not be less than shown in Table 4 for each grade and type when determined in accordance with Test Method B328~~—For each bearing material, the oil content of the as-received bearing shall not be less than the minimum percentage listed in Table 1.

~~7.~~

8.2 *Impregnation Efficiency*—A minimum of 90 % of the interconnected porosity in the as-received bearings shall be impregnated with lubricating oil.
8.3 *Impregnated Density*—The density of the sample bearings, when fully impregnated with lubricating oil, shall meet the requirements prescribed in Table 1 for each bearing material.

9. Mechanical Properties

~~7.1The manufacturer and purchaser shall agree on the number of sample bearings to be taken at random from each lot for~~

~~quantitative determination of mechanical properties by destructive tests.~~

~~7.2~~

9.1 *Radial Crushing Strength*—~~Radial crushing strength in psi or Mpa is the mechanical property by which the strength of oil-impregnated P/M bearing material is characterized and evaluated. It is determined by breaking plain, thin-walled bearings or hollow cylindrical test specimens under diametrical loading, following the procedure described in Test Method B939, and calculating the radial crushing strength according the material strength formula contained herein.~~

~~7.2.1Plain sleeve bearings and thrust bearings are tested in the oil-impregnated condition. For acceptance, the radial crushing strength, determined on the test bearings, shall not be less than the minimum strength specification value listed in Table 5 for the grade and type of bearing material.~~

~~7.2.2Flanged oil-impregnated bearings shall be tested by cutting off the flange and crushing the body as a plain sleeve bearing. For acceptance, the radial crushing strength so determined shall meet the minimum material strength requirements prescribed in Table 5~~—The radial crushing strength of the oil-impregnated bearing material determined on a plain sleeve bearing or a test specimen prepared from a flange or spherical bearing shall meet the minimum and maximum (if required) strength values listed in Table 1.

10. Dimensions, Mass, and Permissible Variations

10.1 This standard is applicable to bronze-base PM sleeve and flange bearings having a 4 to 1 maximum length to inside diameter ratio and a 24 to 1 maximum length to wall thickness ratio.

10.2 Sleeve, flange, thrust and spherical PM bearings covered by this specification are illustrated by Figs. 1-4. Most PM bearings are small and weigh less than one-quarter pound (~100 g) but they can be produced in sizes that will accommodate shafts up to approximately 8 in. (200 mm) in diameter.

10.3 Permissible variations in dimensions shall be within the tolerance limits shown on the bearing print accompanying the order or shall be within the limits specified in the purchase order or contract. Dimensional tolerances of bearings for military or government applications shall meet the requirements specified in the Supplementary Requirements section.

10.4 Recommended commercial tolerances for bronze-base PM bearings are referenced throughout the tables in Appendix X2.

10.5 Chamfers of 30-45° are generally used on PM bearings to break the corners.

11. Workmanship, Finish and Appearance

11.1 The bearings should have a matte surface and not show oxidation. The surfaces of sized bearings should have a smooth, bright finish.

11.2 When cut or fractured, the exposed surface of the bearings should exhibit a uniform visual appearance.

11.3 If metallographic examination is performed to determine degree of sintering, it should be done at 200-400× magnification. In 90Cu-10Sn bronze bearings, the microstructure should be alpha bronze with no silver-gray tin-rich copper compounds and with a minimum of reddish copper-rich areas. The structure should have a very minimum number of original particle boundaries. Diluted Bronze material should show a bronze phase with no visible free tin, dispersed throughout an iron matrix.

11.4 To verify that oil is present, heat the bearing to about 300°F (150°C) for 5 minutes. If oil is present, the bearing surfaces exhibit beads of oil being exuded from the pores.

11.5 When bearings are ordered as being "dry-to-the-touch" to allow automated handling by the purchaser, the excess surface oil is normally removed by a centrifugal operation. It is important that the Oil Content test (13.3.2) be performed after the surface drying treatment to make certain that the required volume of lubricating oil is present.

12. Sampling

12.1 *Lot*—Unless otherwise specified, a lot shall be defined as a specific quantity of bearings manufactured under traceable, controlled conditions as agreed to between the producer and user (Terminology B 243).

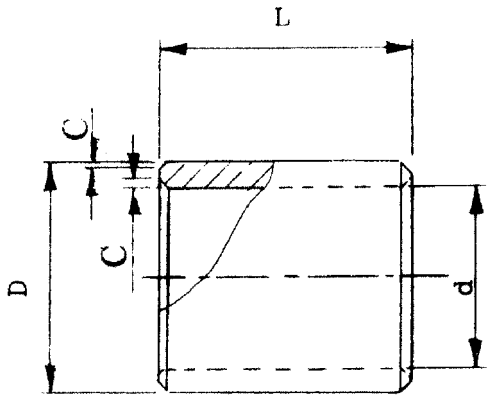

FIG. 1 Standard Sleeve Bearing

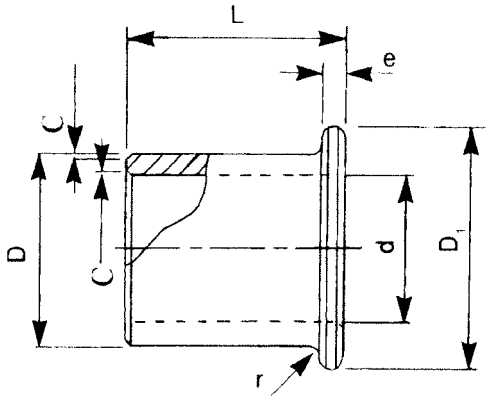

FIG. 2 Standard Flange Bearing

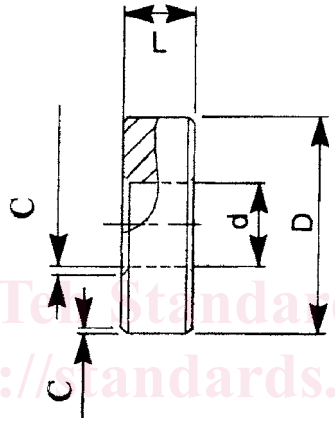

FIG. 3 Standard Thrust Bearing

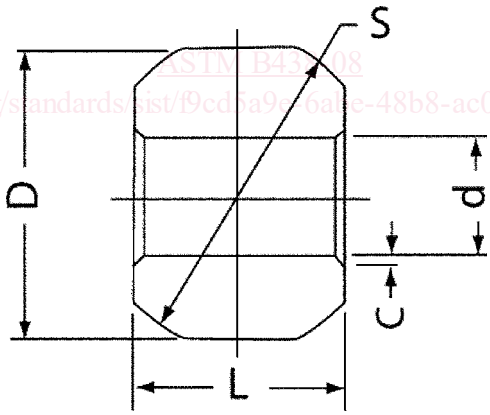

FIG. 4 Standard Spherical Bearing

12.2 *Sampling Plan*—The number of sample bearings, agreed to between the manufacturer and the purchaser, to be used for inspections shall be taken randomly from locations throughout the lot.

13. Test Methods

13.1 *Dimensional Measurements*:

13.1.1 Using suitable measuring equipment, the inside diameter of the bearings shall be measured to the nearest 0.0001 in. (0.0025 mm). The other bearing dimensions only require instrumentation capable of measuring to the tolerances specified on the bearing drawing.

13.2 *Chemical Analysis*:

13.2.1 *Oil Extraction*—Bearings must be dry and free of oil before running chemical tests. To remove oil, a Soxhlet Apparatus as specified in Test Method B 328 may be used. However, upon agreement between purchaser and supplier, a low-temperature furnace treatment [1000 to 1200°F (540 to 650°C)] with a flowing nitrogen or inert atmosphere may be used to volatilize any lubricant that may be present.

13.2.2 *Metallic Elements*—The chemical analysis of metallic elements shall be performed on an oil-free sample in accordance with the test methods prescribed in Volume 03.05 of the *Annual Book of ASTM Standards* or by another approved method agreed upon between the manufacturer and the purchaser.

13.2.3 *Combined Carbon*—To determine the amount of carbon metallurgically combined with the iron in the diluted bronze materials, a metallographic estimate may be made.

13.2.4 *Graphitic Carbon*—Determine the total carbon content in accordance with Test Method E 1019 with the exception that a sample as small as 0.25 g may be used upon agreement between customer and supplier. With the exception of diluted bronze, the graphitic carbon provides an estimate of the total carbon. For diluted bronze, the graphitic carbon is approximately equal to the total carbon minus the combined carbon as determined in 13.2.3.

13.3 *Physical Properties*:

13.3.1 *Oil Content*—The oil content of the as-received bearing shall be determined following the procedure for *Oil Content by Volume as Received* in Test Method B 328.

13.3.2 *Impregnation Efficiency*—The efficiency of the oil-impregnation process in volume percent units shall be calculated as the ratio of the *Oil Content by Volume as Received to the Interconnected Porosity* using the procedures and formulas in Test Method B 328.

13.3.3 *Impregnated Density*—The impregnated density of the sample bearings in g/cm^3 units, measured after they have been fully impregnated, shall be determined following the procedure for *Wet Density* in Test Method B 328.

13.4 *Mechanical Properties*:

13.4.1 *Radial Crushing Strength*—Radial crushing strength in psi (MPa) is the mechanical property by which the strength of oil-impregnated PM bearing material is characterized and evaluated. It is determined by breaking plain thin-walled bearings or hollow cylindrical test specimens under diametrical loading, following the procedures described in Test Method B 939, and calculating the radial crushing strength according to the material strength formula contained therein.

13.4.1.1 Plain sleeve bearings and thrust bearings are tested in the oil-impregnated condition. For acceptance, the radial crushing strength, determined on the test bearings, shall not be less than the minimum nor more than the maximum (if applicable) strength specification values listed in Table 1 for the bearing material.

13.4.1.2 Flanged oil-impregnated bearings shall be tested by cutting off the flange and crushing the body as a plain sleeve bearing. For acceptance, the radial crushing strength so determined shall meet the minimum and maximum (if applicable) material strength requirements prescribed in Table 1. The testing procedure and material strength requirements of the flange shall be a matter of agreement between manufacturer and purchaser.

~~7.2.3~~13.4.1.3 To evaluate ~~spherical bearings~~ spherical, or ~~those~~bearings of other configuration, a number of sample ~~parts~~bearings from the lot shall first be machined to a right circular cylinder, measured, and then crushed to determine the radial crushing strength of the oil-impregnated bearing material. This value shall not be less than the minimum nor more than the maximum (if applicable) radial crushing strength specified in Table ~~5~~1 for the ~~grade and type of the~~ material in the ~~spherical bearing.~~sample bearings.

~~7.3~~13.4.2 *Bearing Breaking Load*—If agreed to by the manufacturer and the purchaser, an acceptance specification for the minimum (maximum) bearing breaking load, $P_{min,}$ ~~—~~ (P_{max}) in lbf ~~or N,~~ (N), may be established for any specific standard oil-impregnated bearing. This simplifies acceptance testing because the decision is now based solely upon reading the output of the testing machine without a need for further calculations. This acceptance procedure can be very useful when evaluating multiple or repeat shipments of the same bearing.

~~7.3.1 The~~13.4.2.1 The minimum (maximum) breaking load, ~~P_{min}~~, $P_{min,}$ (P_{max}) required for acceptance of any specific plain sleeve or thrust bearing is calculated using the breaking load formula:

$$P_{min}=K\times L\times t^2/(D-t) \quad (1)$$

min, Pmax = K × L × t2D – t

where:

P_{min}*min, (P max)* = minimum (maximum) bearing breaking load, lbf ~~or N,~~ (N),

K = ~~radial crushing strength, psi or MPa,~~ minimum (maximum) radial crushing strength, psi (MPa),

L = ~~length of bearing, in. or mm,~~ length of bearing, in. (mm),

t = ~~wall thickness (t = (D – d)/2), in. or mm,~~ wall thickness, [$t = (D - d) / 2$], in. (mm),

D = ~~outside diameter, in. or mm, and~~ outside diameter, in. (mm), and

d = ~~inside diameter, in. or mm.~~inside diameter, in. (mm).

13.4.2.2 Use the minimum (maximum) radial crushing strength value specified for the ~~grade and type~~ oil-impregnated bearing material from Table ~~5~~1 for K, use the actual D, d ~~, and~~ *and* L ~~dimensions of the as-received bearing and solve for P_{min}. This calculated value will be the minimum acceptable breaking load for that specific plain bearing.~~

~~7.3.2 The minimum acceptable breaking load for a specific flanged bearing shall be determined by first cutting off the flange and measuring the~~ *dimensions of the as-received bearing and solve for* $P_{min,}$ (P_{max}). This calculated value will be the minimum (maximum) acceptable breaking load for that specific plain bearing. Using the allowable print dimensions that minimize

(maximize) the volume of the bearing for the calculations will result in a breaking load specification(s) that will be applicable to any lot of that specific bearing.

13.4.2.3 The minimum (maximum) acceptable breaking load for a specific flanged bearing shall be calculated by first cutting off the flange and measuring the *D*, *d* ~~, and~~ *and L* of the body. Then, using the minimum (maximum) radial crushing strength for the ~~grade and type of~~ oil-impregnated bearing material ~~from~~ in Table ~~5~~1 for *K* in the breaking load formula and the measured dimensions of the body, a $P_{min,}$ (P_{max}) value may be calculated. This will be the minimum (maximum) bearing breaking load required for the body of that specific flanged bearing. The test procedure and breaking load requirements for the flange shall be a matter of agreement between purchaser and manufacturer.

~~7.3.3For~~13.4.2.4 For acceptance testing of whole spherical bearings, a minimum (maximum) bearing breaking load specification, $P_{min,}$ ~~–~~ (P_{max}) may be established on a specific whole spherical oil-impregnated bearing. First, the radial crushing strength, K_a, is determined on that specific spherical bearing machined to a ~~right circular~~ plain cylinder as in ~~7.2.3~~13.4.1.3. Second, whole spherical bearings from the same lot are crushed, keeping their axes horizontal, to determine the breaking load of the whole bearing. Then, using the correlation formula, the specifications for the breaking load, P_a, of that whole spherical bearing ~~is~~are calculated as follows:

$$P_{min} = K \times P_a / K_a \quad (2)$$

min, Pmax = K × PaKa

Pmin, (P max)

where:

P_{min} = specification for the minimum (maximum) bearing breaking load of a specific whole spherical bearing, lbf ~~or N,~~ (N), *min, (P max)*

K_a = radial crushing strength of the machined test spherical bearings according to ~~7.2.3~~13.4.1.3, psi ~~or MPa,~~ (MPa),

K = ~~radial crushing strength for the grade and type of bearing material from Table 5, psi or MPa, and~~ minimum (maximum) radial crushing strength for the bearing material, (Table 1), psi (MPa), and

P_a = breaking load of whole test spherical bearings, lbf ~~or N.~~(N).

~~8.Chemical Analysis~~

~~8.1If required by purchase agreement, one sample for chemical analysis shall be taken from each lot. A representative sample of chips may be obtained by milling, drilling, filing, or crushing a bearing with clean dry tools without lubrication. To obtain oil-free chips, the parts selected for test shall have the oil extracted in accordance with Test Method B328 if necessary.~~

~~8.2The chemical analysis shall be made in accordance with the methods prescribed in Vol 03.05 of the *Annual Book of ASTM Standards* or by any other method agreed upon between the manufacturer and the purchaser.~~

~~9.Dimensions and Tolerances~~

~~9.1Permissible variations in dimensions shall be within the limits specified on the drawings describing the bearings accompanying the order or shall be within the limits specified on the order.~~

~~10.Workmanship, Finish, and Appearance~~

~~10.1Bearings shall be uniform in composition, clean, and conform to applicable drawings.~~

~~11.Sampling~~

~~11.1*Lot*—Unless otherwise specified, a lot shall consist of parts of the same form and dimensions made from powders of the same composition, formed and sintered under the same conditions, and submitted for inspection at one time.~~

~~12.Inspection~~

~~12.1Unless otherwise specified, inspection of parts supplied on contract shall be made by the purchaser at the destination.~~

~~13.Rejection~~

~~13.1Parts that fail to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing.~~

13.5 *Conformance*:

13.5.1 *Dimensional Measurements*—For purposes of determining conformance with the dimensional specifications, the tolerance limits specified on the bearing print are considered absolute limits as defined in Practice E 29.

13.5.2 *Chemical, Physical, Mechanical Test Results*—For purposes of determining conformance with these specifications, an observed value or calculated value shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E 29.

13.5.3 *Measurement Uncertainty*—The precision and bias of the test result values shall be considered by the purchaser and supplier in determining conformance.

14. Certification

14.1When specified in the purchase order or contract, a producer's certification shall be furnished to the purchaser that the parts were manufactured, sampled, tested, and inspected in accordance with this specification and have been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

14.2The purchase order must specify whether or not the certification includes chemistry.

14.3Upon request of the purchaser in the contract or order, the certification of an independent third party indicating conformance to the requirements of this specification may be considered. Inspection

14.1 The manufacturer has the primary responsibility to conduct the necessary measurements and tests to ensure that the bearings meet the requirements of the purchase order or contract and this specification before they are shipped to the customer.

14.2 Provided the manufacturer notifies the purchaser, all or a portion of the required conformance tests may be contracted to a qualified third party.

14.3 Upon receipt of the shipment, the purchaser may conduct whatever quality control inspections that he feels are necessary to confirm compliance to the purchasing requirements.

15. Supplementary Requirements

15.1For some materials, supplementary requirements may be specified. Usually these apply only when specified by the purchaser in the inquiry, contract, or order. These supplementary requirements shall appear separately.

15.2*Special Government Requirements*—Requirements that are special to government needs are listed in 15.2.1 through 15.2.9.

15.2.1Materials shall conform to Table 1, Grade 4. Contractor shall furnish a percent composition analysis on an oil-free basis for each lot showing the percentage for each element as specified in Table 1. Bearing shall conform to this specification and supporting military specification as applicable.

15.2.2High-grade non-gumming petroleum lubricants, such as MIL-PRF-6085, MIL-PRF-17331 (Military Symbol 2190–TEP), or as specified on referenced military standard specification sheets shall be used to impregnate the bearings.

15.2.3When specified, a first-article inspection shall be performed on bearings. Four samples shall be made available for first-article inspection and tested for chemical requirements, density, porosity, radial crushing strength, oil excretion, and dimensional characteristics as specified herein, Test Method B328, FED-STD-151, or in an otherwise specified document. Any defect or failure shall be cause for rejection of the lot. Waivers for minor defects may be addressed to the contracting officer.

15.2.4When procured from a contractor versus the actual manufacturer, a certificate of quality conformance (COQC) supplied by the manufacturer of the bearing may be furnished in lieu of actual performance of such testing by the contractor, provided lot identity has been maintained and can be demonstrated to the Government. The certificate shall include the name of the contractor, contractor number, name of manufacturer, NSN, item identification, name of the component or material, lot number, lot size, dimensions, date of testing, test method, individual test results, and specification requirements.

15.2.5When specified in the contract or purchase order, packaging and marking shall be completed in accordance with the provisions of the contract.

15.2.6Oil excretion of the bearing shall be verified by placing the bearing in the chamber of a preheated oven. Oven temperature shall be nominally 300°F [149°C]. Exposure shall be 5 min. During the period, beads shall exude uniformly from the bearing surface. Lack of appreciable sweating of the lubricant on the bearing surface will be cause for rejection. Lubricant content may be verified using Test Method B328.

15.2.7Unless otherwise specified, the contractor is responsible for testing. The contractor may use their own or any other suitable facility for the performance of testing and inspection, unless an exception is stated. The Government reserves the right to perform an inspection set forth herein to assure supplies and sources conform to the prescribed requirements.

15.2.8Records of examination and tests performed by or for the contractor shall be maintained and made available to the Government by the contractor for a period of three years after delivery of the products and associate material.

15.2.9All requirements shall be as specified herein. Reference military standard specification sheets shall take precedence unless otherwise specified in the contract or purchase order. Rejection and Rehearing

15.1 Rejection based on tests made in accordance with this specification shall be reported in writing to the manufacturer within 30 days of receipt of the shipment; the rejected bearings, however, shall not be returned or disposed of without written authorization from the producer.

15.2 In case of dissatisfaction with the test results, either the purchaser or manufacturer may make a claim for rehearing.

16. Certification and Test Report

16.1 The purchaser may require in the purchase order or contract that the manufacturer shall supply a Certificate of Compliance stating that the bearings were produced and tested in accordance with this specification and met all requirements.

16.2 In addition, when required by the purchase order or contract, the manufacturer shall furnish a Test Report that lists the results of the chemical, physical, mechanical and functional tests performed on the sample bearings.

16.3 When required, the Certificate of Compliance or the Test Report, or both may be transmitted by electronic service.

17. Packaging

17.1 Unless specific packaging requirements are included in the purchase order or contract, the finished oil-impregnated PM

bearings shall be packaged and shipped in containers of a nonabsorbent material to prevent loss of lubricating oil.

18. Keywords

~~16.1bearing breaking load; density; *K*, radial crushing strength, porous metallic bearings, strength constant; oil content; oil-impregnated bearings; P/M bearings; porosity~~

18.1 bearing breaking load; bronze bearings; impregnated density; interconnected porosity; oil content; oil-impregnated bearings; open porosity; porous metallic bearings; radial crushing strength; self-lubricating bearings; PM bearings; PV Factor; PV Limit;

SUPPLEMENTARY REQUIREMENTS

MILITARY BEARINGS, SINTERED BRONZE, OIL-IMPREGNATED

The following supplementary requirements shall apply to purchase orders or contracts from all agencies of the United States Government or where specified by a purchaser as part of the purchase order or contract with a government agency.

S1. Introduction

S1.1 The B 438 purchasing specification incorporates and updates the applicable portions of specifications from MIL-B-5687 (revision D, dated 21 February 1984), MS17795 (revision A dated 14 February 1962), MS17796 (revision B w/Amendment 1, dated 14 Jul 2004) and MS21783 (basic document, dated 21 February 1984) bringing the military requirements into alignment with the rest of this consensus specification. The type and grade designations from MIL-B-5687 have been converted to the industry accepted material designation codes from MPIF Standard 35 (Bearings) (see Table A2.1 for conversion information). In addition to meeting the primary specifications, the purchaser of bearings for military or government applications must comply with additional specific requirements. This Supplementary Requirements section details those additional governmental requirements.

S1.2 The bearings referred to within this specification are not intended for reaming on assembly.

S1.3 The bearings referred to within this specification are not recommended for military airframe applications.

S2. Government Requirements

S2.1 *Chemical, Physical and Mechanical Requirements*—Refer to Section 1 and Table 1 for the specifications for bearing materials that shall conform to material designation codes CTG-1001-K23 (sleeve, flange and thrust washer) or CTG-1001-K23-MOD (sleeve and flange only). The contractor shall furnish a chemical composition analysis on an oil-free basis for each lot showing the weight percentage for each element as specified in Table 1. Bearings shall conform to this specification.

S2.1.1 *Compressive Yield Strength*—The yield strength in compression shall be 11 000 psi (75 MPa) (minimum) for 0.1 percent permanent offset in accordance with section X3.2.1.

S2.1.2 *Surface Finish*—For thrust washer bearings, all surfaces shall have a surface finish of 125 µin. maximum except as noted on a print or drawing. Surface finish shall be measured in accordance with Test Method B 946.

S2.2 *Oil-Impregnation*—High-grade non-gumming petroleum lubricants purchased in accordance with the applicable Qualified Products Lists (QPLs), such as MIL-PRF-17331 (Military Symbol 2190–TEP, NATO Code O-250 and QPL-17331) for sleeve and flange bearings and MIL-PRF-6085 (Military Symbol OAI, NATO Code No. 0-147 and QPL-6085) for thrust washer bearings, or as specified on referenced military standard specification sheets shall be used to impregnate the bearings.

S2.3 *First Article Tests (FAT)*—When specified in the contract, FATs shall be performed on a number of samples (four minimum). The tests performed shall conform to 12.2, Sampling Plan and shall include testing for interconnected porosity. Testing shall be as specified within this specification, Test Method B 328 or in another document as specified in the contract. Any defect or failure shall be cause for rejection of the lot. Waivers for minor defects may be addressed to the contracting officer.

Note—In order to perform all the tests on a single bearing, the following order of tests is suggested: dimensional, impregnated density, interconnected porosity, oil content, oil exudation, radial crushing strength and chemical analysis.

S2.4 *Oil Exudation Test*— During the test period for oil exudation, beads shall exude from the bearing surface. Lack of appreciable sweating of the lubricant on the bearing surface will be cause for rejection (see 11.4).

S2.5 *COQC*—When procured from a dealer or distributor versus the actual manufacturer, a certificate of quality conformance (COQC) supplied by the manufacturer of the bearing may be furnished in lieu of actual performance of such testing by the dealer or distributor, provided lot identity is traceable, has been maintained and can be demonstrated to the Government. The certificate shall include the name of the dealer or distributor, dealer or distributor number, name of manufacturer, national stock number (NSN), item identification, name of the component or material, lot number, lot size, dimensions, date of testing, test method, individual test results, and specification requirements.

S2.6 *Records*—Records of examination and tests performed by or for the contractor shall be maintained and made available to the Government by the contractor for a period of three years after delivery of the products and associate material.

S2.7 *Inspection*— Unless otherwise specified, the manufacturer is responsible for testing. The manufacturer may use their own or any other suitable facility for the performance of testing and inspection, unless an exception is stated. The Government reserves

the right to perform an inspection as set forth herein to assure supplies and sources conform to the prescribed requirements.

S2.8 *Packaging*—Special packaging and marking requirements shall be included in the contract or will conform to Section 17, Packaging.

S2.9 *Requirements*—All requirements shall be as specified herein. Referenced military standard specification sheets shall take precedence unless otherwise specified in the purchase order or contract.

S3. Ordering Information

S3.1 *Purchase Order or Contract*—Ordering information shall be in accordance with Section 5 of this specification and shall also include:

S3.1.1 PIN from S3.3, Table S3.1, Table S3.2 or Table S3.3,

S3.1.2 National Stock Number (NSN),

S3.1.3 Quantity,

S3.1.4 Requirements for testing including FAT,

S3.1.15 COQC if required, and

S3.1.6 Packaging requirements, if different from Section 17.

S3.2 *PIN*—The military PIN shall consist of the letters and numbers representing the old MS documents and taken from the titles of Table S3.1 (for sleeve), Table S3.2 (for flange) or Table S3.3 (for thrust washer), a dash number from either Table S3.1 (for sleeve), Table S3.2 (for flange) or Table S3.3 (for thrust washer) and a suffix of Y or Z representing the material designation code.

Example: MS17796 − 104 − Y

where:

MS17796	=	the number from Table S3.1 or Table S3.2 or Table S3.3 representing the old MS document,
104	=	Dash number, from Table S3.1 or Table S3.2 or Table S3.3,
Y	=	Material Designation Code: Y = CTG-1001-K23 Z = CTG-1001-K23 MOD

Note—The MS17796–104–Y part identification number (PIN) equates to the old MS17796-104 designation where the MS17796 represented the military standard number for flange bearings (sleeve and thrust bearings are described in MS17795 and MS21783 respectively), the 104 was the dash number; as for the suffix Y, it is new; in MS17796, the material designation code was called out separately as a Grade and Type and was not a part of the PIN but was part of the required ordering information. The dash numbers themselves remain unchanged from those in MS17795, MS17796 and MS21783.

S3.3 *Dimensions and Dash Numbers:*

S3.3.1 *Sleeve Bearings*—Refer to Fig. 1 and Table S3.1—Standard Military Bronze Sleeve Bearings–Dimensions and Dash Numbers.

S3.3.2 *Flange Bearings*—Refer to Fig. 2 and Table S3.2 —Standard Military Bronze Flange Bearings–Dimensions and Dash Numbers.

S3.3.3 *Thrust Washer Bearings*— Refer to Fig. 3 and Table S3.3—Standard Military Bronze Thrust Washer Bearings–Dimensions and Dash Numbers.

S3.4 *Tolerances*—Refer to Table S3.4—Required Dimensional Tolerances.

S3.5 *Chamfers*—Refer to Table S3.5—Chamfers.

S3.6 *Documents*— Referenced documents shall be of the issue in effect on the date of invitations for bids or request for proposals, except that referenced, adopted industry documents shall give the date of the issue adopted. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence.